

Wireless Network Design Considerations

1.0 Overview

1.1 Introduction

In a wireless network design, there are several factors to consider. This document is broken into sections to provide a series of questions for fact finding to better address wireless design concerns.

The questions listed were primarily referenced in Gartner Research paper G00171433 *Toolkit: Technology Section of a WLAN RFP* as well as Gartner Research paper G001261303 *Network Access for Guests or Contractors Requires More than an Open Network Coffee-Shop Strategy* and supplemented by conversations with Gartner Fellow Tim Zimmermann and WNYRIC staff.

1.2 Document intention

- The intent of this document is to provide an overall questionnaire;
 - To aide a proper wireless network design
 - To elicit district input to design decisions,
 - To document the decisions the district chose,
 - And to provide a default answer in absence of district input.
- *It is important to understand this document is intended to solicit input and design criteria to determine a proper solution based on the district requirements. It is not intended to conflict with past recommendations as those were developed with older technology and different design decisions.*
- This is intended to be a “living” document, evolving with changing district requirements and technology advancements.

2.0 The End-User Experience (this is the key to a successful design)

- Dictates what to install -
 - What users?
 - What devices?
 - That are doing what

2.1 User counts and type determination

- Who are the wireless users and what uses/applications will they need from the wireless network?
 - I.e. Students, Teachers, Office Staff, Guests, Contractors, Vendors, Facility, Support Staff, etc.
 - I.e. Internet, videoconference, VoWLAN, assessment testing, file transfers, online testing, etc.
- Are there wireless units such as printers, control systems, cameras, MiDi, Widi, TVs that will use the wireless network?
- What are the "lite client" devices (i.e.; Chromebooks, iPads, etc) and are Cloud Applications to be utilized.
- What is the best estimate for growth in the next few years for both users and capacity?

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Default design without specific input

- *Plan that all students and staff will use the wireless network.*
- *Plan that visitors and guests will use a segregated wireless network.*
- *Plan for 3 or 4 devices per 1 user ratio.*

2.2 Per-User Capacity Planning

- What are the current and potential applications and usage scenarios?
- What WLAN requirements are associated with each application?
- What is the peak, average, concurrent capacity or throughput is needed by each type of user, in each application scenario?
 - Wave 1 is now available, be aware that 802.11 ac wave 2 is scheduled for ratification in fall 2015. Be aware that upgrade on Wave 1 equipment to Wave 2 might not be feasible due to the anticipated minor performance increase moving to first rev of Wave 2.
- Configure QOS for Wireless VoIP. (How many VoIP devices)
- Configure QOS for Wireless Video. (What's the video application).
- Configure correctly for all real-time applications.

Default design without specific input

- *Plan on 5 Mbps per user concurrently.*
 - *This means using 802.11n and 802.11ac wave 1 and wave 2 (pending) rather than 802.11g which only allows support 5 devices per AP at 5 Mbps.*
 - *Reduce or dial down receive capability on beacon*
 - *Beacon should be set to the lowest supported rate*
 - *Lowest mandatory rate*
 - *Turn off 1 & 2 mbps (support only 11+ mbps)*
- NOTE: *D-tim setting is the beacon frequency not beacon rate*
- *Configure QOS for Wireless VoIP.*
 - *Use band select as opposed to load balancing – if density is at 1 AP per classroom then you can use load balancing configure as: up users to 20 and denies to 1*
- *If using 802.11ac – use 40 MHz wide channels to get full bandwidth and 40MHz for N.*
- *Ensure channel scanning is off for all real-time applications – or implement dynamically configuration of ARM if its supported*
- *Coverage vs. capacity*
 - *5 mbps per user x 4 devices each*
- *Many WLANs have been designed for "connection" and not for "capability." Designed for connections means capacity.*
- *Coverage indicates clients are able to connect to the wireless infrastructure, and, although the access point can transmit up to 54 Mbps in an 802.11g environment, the user may experience only 1 Mbps of raw throughput.*
 - *Turn off 1 & 2 mbps (support only 11+ mbps)*

Wireless Network Design Considerations

2.3 Coverage Areas and Density

- Are there building diagrams? Are they dimensioned properly?
 - Are there CAD/building material drawings that can be imported into a design-planning tool? (use a base format of PNG or JPG)
 - Lacking the CAD drawings, are their other building diagrams available in JPEG format for hand drawings?
 - Are the wiring closet locations and cable locations known, documented, and marked appropriately on diagram?
- Where, when and for what purpose will the wireless network be used?
- How many users/devices will be using the wireless network in what locations?
- Are there privacy and security Board Policies in place in the district today, if so, what are these?
- Is the district willing to invest in a predesign wireless site survey to determine current coverage and availability?
- Will the district invest in a wireless site survey on an annual basis?
- Collect mounting location info - Permitted AP installation locations (Ceiling or Wall or both). Determine mounting options per AP location.

Default design without specific input

- ***A full pre Site Survey is not necessary if planning a 1 AP per room configuration. But location based surveys are recommended for use in specific areas of concern; validating with spectrum analysis.***
- ***The upcoming 2.5G ("MultiGig") wired standard will allow of single Cat5e or Cat6 runs per classroom. Plan 1 AP and 2 Cat6a cable drops per classroom and office area for redundancy purposes.***
- ***AP's should be ceiling mounted, unless specifically designed for horizontal propagation.***
- ***Design Density based on 35 concurrent active clients per AP due to sequenced usage in K-12 environments.***
- ***Purchase current technology - AC wave 1 or wave 2(not ratified as of date of the document)***
 - ***AC wave 1- can handle 200 associations per AP – 50 to 75 of pure web-traffic.***
- ***Plan to support 500 or more client devices in large areas such as auditorium, (design and build to capacity) cafeteria, gymnasium, and athletic fields. Auditoriums should consider radio strength, but it is less about radio strength and more about channel use. Depending on environment Directional Antennas should help.***
 - ***3 - 4 to AP's per Auditorium using 40 MHz wide channels***
 - ***5 + AP's use 20 MHz – avoiding DFS channels***
- ***For super High Density areas consider directional antennas***
 - ***30-60 degree antennas in a grid pattern on ceiling***
 - ***Use external directional antennas.***

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- *If using Omni-directional use 20 GHz as 20 Ghz channels will increase service to everyone.*
- *Each vender has multiple options for models of AP's*
 - *When price constraints are an issue planning for specific device types for specific applications or areas.*
 - *Only run 3 channels of 2.4 no more*
- *A post installation wireless site survey will be performed to audit and remediate installation and provided as a "living document" to the school district. This should be performed during school hours under normal load conditions.*
- *Schedule annual site survey at time of project completion.*
- *DO NOT use mobile AP's such as AP on a mobile cart. It causes interference and changes the wireless environment*
- *Purchase 5% additional AP's units for design supplement and testing. AP power level set to make weakest client (generally 15dBm as this is the best case).*

Default design

- *Transaction density will be determined by the client density and user/application capacity needs.*
- *Normally minimal considered need be applied in a 1 AP per classroom design.*

2.5 Definition of Types of Clients

- What types of client devices will be using the wireless network? What type of radios, antennae and transmit power is available in the clients?
 - I.e. laptops, desktops, tablets, smartphones, VoWLAN handsets, wireless network printers and scanners, security cameras, Wi-Fi active RFID tags, MiDi, Widi, TVs.
- What devices will be configured for 802.11b/g, 802.11a, 802.11n, and/or 802.11ac in what frequency ranges of 2.4 GHz and 5.0 GHz?
- What type of devices should be denied from Wireless Access?
 - i.e. never an Nintendo DS
 - Are all "B" channel devices to be eliminated?
 - What can you eliminate in the 2.4 GHz spectrum?
 - Are there currently AP's on carts?

Default design without specific input

- *Plan for 1st and 2nd Gen iPads, which have a single radio with the weakest transmit power of most devices.*
- *Don't use mobile AP's in a pure environment*
- *Match – power output to lowest power output client*
 - *Consider 10 dBm but plan for max AP power level of 15dBm.*
- *1 AP per class - uni1 and uni3 20GHz wide channels, 12+ Mps power at 15dBm Use dynamic channel selection to install then turn auto channel selection off making them static.*

Wireless Network Design Considerations

- *This will help eliminates roaming issues by making roaming very deliberate.*
- *Utilize and plan to migrate to the 5Ghz spectrum when possible. (Ensure 5 Ghz spectrum is louder than 2.4Ghz spectrum).*
 - *Run 5.0 at a higher power than 2.4*
 - *ARM power levels at 12-15 for 5.0*
 - *2.4 - 9-12 dBm*
 - *Assuming a 1 AP per room coverage model*
- *Recommend 802.11 ac and eliminate 802.11b/g/a systems.*
- *Minimize all 802.11g systems and 2.4 GHz 802.11n if they can't be eliminated. (Even with non legacy equipment, clients can still prefer 2.4 GHz. Designing for a louder 5 GHz space and leveraging Client-Match technology will ensure optimal Client connection).*
- *Remove legacy data rates and raise beacon rate to support mitigation of B*
 - *Beacon rate should match lowest data rate!*
 - *Rate to 11 meg to still support B for guest*
 - *If B is eliminated – go to 12 mbps*
- *Ensure client drivers and software are regularly scheduled and updated to latest approved releases.*
- *Reduce max power to match weakest client*
 - *100 mW = 20DBN*
 - *iPAD is would be 13 to 14 dBn's = 25 mW*

** Recommend wiring any potential wireless units such as printers, interactive learning devices, control systems, cameras, MiDi, Widi, TVs.*

3.0 Environmental and Operating Conditions

3.1 Site Survey and Monitoring

- What is the environmental noise floor for the areas where the WLAN will be installed for 2.4GHz and 5GHz?
- What is the signal-to-noise ratio policy for the district? Post-Surveys can be completed to determine low SNR.
- Do any areas require special antennas?
- Has a spectrum analysis been done as part of a wireless site survey?
- What will be the ongoing plan for non-WiFi interference monitoring?
 - Term Clarification: Rogue AP Neighbors are interfering AP's
 - Rogue implies the device is on your Network at the same time
 - District should have a policy that disallows HOT-SPOTS, and Rogue AP's – or Honey Pots (neighbors offering same SSID as district)
- End point management should be implemented to control wireless network space/ networks are accessed either through vender specific options or GPO's.

Default design without specific input

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- *Use a signal-to-noise ratio of 25 dB (Depending on noise floor this could be relatively low signal boundary)*
- *Without a specific survey, design 1 AP per room*
- *Optionally, use Ekahau or AirMagnet planning tools for design.*
- *Consider IDS if the schools Rogue AP policies allow for rogue devices.*
- *Provide a means to perform spectrum analysis and interference monitoring both pre and post installation.*
 - *Use AP's with built in function or use on-site probes*
- *Consider dedicated AP for dedicated spectrum analysis*
- *End point management should be implemented to control wireless network space/ networks are accessed either through vender specific options or GPO's.*
- *NOTE: Outside of placing an AP per classroom model, always Survey using 5 GHz only with AP power levels of 15dBm and signal boundary of -68dBm. For VoIP planning leverage the same as above but -65dBm cell boundary.*

3.2 Linking the WLAN Components to the Wired Infrastructure

- Is there proper wiring to connect the proposed AP locations?
 - Will the wire support gigabit Ethernet?
 - Cat 6a cabling is recommended due to distance limitations with 10 Gb throughput
- Plan on needed POE+ 30 Watts per port to power AP's with AC Radio's
- Can the district provide clean and consistent power to the AP's and PoE switches?
- Is there a need for dual wires to each AP to ensure future growth? Dual wires to each AP is suggested
- Is there a plan or process to put in new cabling if needed (capital project)?
- Are there other devices that require PoE as well, such as security cameras?
- Can the design support the new standard for approx 2.5 GB over existing cabling? (Cat5e will support 2.5G Ethernet at 100m distances).
- Is there a proper count and wiring design to show how many powered devices will be in each wiring closet?
- Is there a need for wired areas that are high density and demand such as AutoCAD labs?

Default design without specific input

- *Add enough switches to the project to provide minimally 24 port PoE+ to each wiring closet. Watch for power allocation, it would be beneficial to increase UPS systems.*
- *Recommend dedicated 2 Cat6a wiring drops to each AP.*
 - *Dual Drops support multi-homing to controllers and Redundancy*
 - *Do not repurpose a desktop drop unless it is relocated.*

Wireless Network Design Considerations

- *Wiring drop must have female end to allow for 15' service loop (patch cable).*
- *Without cabling plan the only option would be to identify if there is an existing drop to the locations that can be used.*
- *Allow for multiple ports in core of network with a minimum 4 port Link Aggregation Group (LAG), recommend 2 x 10 GB between the wireless controller and core network switches.*
- *Assume the district has good and consistent power for AP's and PoE switches with UPS in every closet and generator backup. Budget for 3 year life cycle on Batteries.*
- *Research Energy efficient standards like Energy wise as an option.*

3.3 High availability

- What level of reliability should the infrastructure be designed to accommodate?
- Is overlapping coverage of adjacent access points required?
- Wireless controller redundancy with redundant power supplies is preferred
- If there is a problem with the Ethernet cabling, is a wireless mesh, which allows the access points to communicate to each other required?
- Are multi-homed access points required (i.e., be able to have primary and second wired connections to different upstream switches)?

Default design without specific input

- *Provide fully redundant controllers in HA mode (at a minimum a standby controller to ensure a N+1 configuration)*
 - *The Exception: if moving to controller less model where redundant controllers are not needed because the controller becomes a tool for configuration and changes only, and would exist on a VM instance.*
 - *This can be brick-backed and v-motioned as needed.*
- *Provide multi-homed AP's PoE - as permitted by cabling and manufacturer features i.e.: Active/Standby POE ports on AP.*
NOTE: *Cisco does not support multi-homing or ether channel.*
- *Dual home AP's to controllers using active/standby tunnels.*

3.4 Maintenance and Repair

- What does the district desire for maintenance options?
 - Does the district want a same day or next business day replacement contract, or will the district carry spare components?
 - Does the district have a maintenance plan to keep all wireless network equipment and management components up to date for software?

Default design without specific input

- *Provide same day replacement on controllers.*

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- *Provide licensing of software updates on all components.*
- *Do not purchase maintenance on AP's.*
- *Specifically inquire whether or not the AP's have lifetime replacements.*
- *Lifetime Warranties - create the need to keep a database of SN of AP and LIC activation code.*

3.5 Network Management

- Does the district want to manage the wireless network or does the district wish to contract management?
- Who is responsible in the district for maintaining MAC addresses of district owned devices?
- Is there a need for the Guest Network to be available after hours?
- Is there a need for multivendor support?
 - Please identify all supported vendors.
- Does the wireless network management application need to integrate with the wired enterprise management strategy?
- What is the district policy for rogue AP enforcement?
- Does the district have a policy for working with AP's from the neighborhood and how it interferes with the wireless network?
- How does the district want to identify and replace failed components?
 - Who should get alerts and provide diagnostics?
- Does the district want to enable auto-tuning of the AP's or should that function be provided manually?
- Does the district want historical trend and network usage reporting?
- Does the district desire a post site survey to audit/remediate the design?

Default design without specific input

- *The RIC will manage the system and perform all repairs.*
- *Build a network management system for district use, import diagrams as available, and generate heat maps as capable inputting building materials on the maps as possible.*
- *Rogue AP's will be identified and manually removed if on district property. (Leverage vender specific tools such as "Aruba protect SSID").*
- *Alerts will go to RIC and appropriate district personnel.*
- *The system will be set to 'auto tune.' during installation then moved to auto-tune -off.*
- *A post site survey will be performed and provided to the district. Most manufactures have additional software to help facilitate ongoing maintenance such as Airwave, VisualRF, or Prime Infrastructure.*
- *Schedule annual review and possible site surveys as part of the project.*
- *Perform annual RF Health Check.*

Wireless Network Design Considerations

- *Provide monthly Usage / client health reports.*

3.6 Migration Strategy for Existing Mixed Networks

- Review and Inventory Legacy clients and get a replacement plan
- Are there legacy access points that will remain in service?
 - Is there a desire to keep legacy system in different building?
- Will the new solution manage the legacy AP's?
 - Is it acceptable to have multiple management systems if needed?

Default design without specific input

- *Replace all the existing AP's and controllers to allow for a single system; at a minimum segregate systems by building.*
- *In dense environments – reduce power use 40 MHz wide channels, enable uni-2 extended.*
- *In wave 1 AC use 20 to 40 MHz Depending on AP Deployment Density (IE: AP per Classroom). Consider lowering to 20 MHz Channels if you feel performance degradation. Tailor channel design to environment*
 - *20 MHz for more users/less bandwidth*
 - *40 MHz for less users/more bandwidth*
- *In Wave 2 AC – 160 wide for max bandwidth*
 - *Match N to AC - 40 MHz wide channels during transition*

4.0 Network Services

4.1 Security and Authentication

- Because of rapid changes in Wireless Security and Authentication these questions and recommendations will continue to change in near future.
- Does the district have a Certificate Authority?
- Radius Server should use a registered certificate from a well-known authority. (Wild Card Certs can be used for Controllers or Guest Wireless)
- Does the district use Mobile Device Management?
- Will the client devices support WPA2-AES?
 - Are there clients that do not support WPA2-AES?
- Will the Extensible Authentication Protocol (802.1x) be used?
 - Is the server infrastructure available to support EAP?
 - Does the recommended solution have an integrated RADIUS option, or is an external server required?
 - Are there any limitations associated with the supplicants that can be used?
- Does the district have a policy in place to address BYOD and Guest access?
 - Is there a VLAN structure that will support segregation by firewall and routing segmentation for BYOD, Guest, and Internal devices?
- Is a captive portal guest access solution needed?
 - Does the district require device registration for guest or BYOD access?

Wireless Network Design Considerations

- Is posture checking and device interrogation/remediation desired (OS and patch levels)?
- Radius with districts adding MAC addresses or WAN Senior Network Engineers adding MAC addresses. Can these be uploaded from another network system (DHCP)?
- What is the workstation level login for non-windows systems
- Consider integration with Content Filtering rule sets. This can ensure filtering is effective and reflective of the district policy for students and guest
- Is there a desire for rogue device/AP detection and remediation?
- Will the district get rid of pre-shared keys?

Default design without specific input

- ***Use WPA2-AES and disable TKIP.***
- ***Use 802.1x***
- ***Use registered certificates even if the district has a CA.***
- ***Reduce the number of SSID's by implementing device profiling and QOS prioritize as much as possible.***
- ***Understand that this technology is rapidly changing so a review based on new technology is needed frequently during the planning process.***
- ***Use NAC Authentication system (i.e. Identity Engines, ISE, Bradford, ClearPass, Microsoft NPS)***
 - ***Identify the device ownership by MAC Address using an Mobile Device Management (MDM) Solution***
 - ***i.e.: Aruba exchange (Clearpass external interface to other devices) to determine if device is registered with MDM during login sequence (not mac address based).***
 - ***Identify the user by district directory***
 - ***Leverage machine authentication for district windows devices.***
 - ***Provide differentiated access for faculty over students when using a district device. – using AD attributes***
 - ***Based on the following query do the following***
 - ***Route Guest Vlan to FW with minimum Student or Guest Filtering (Or use vendors NAC appliance's built-in stateful Firewall and role mapping for security)***
 - ***Use vendors NAC appliance's to exchange user identity to supported content aware systems.***
 - ***Allow students owned devices to leverage same secure SSID as school owned devices but restrict access based on identity with role mapping.***
 - ***Use mac caching for guest access to ensure splash page doesn't reappear repeatedly. 6-12 hour cache.***

Wireless Network Design Considerations

- *Provide zero touch guest provision for easy guest access with identity mapping.*
- *Provide differentiated access for contractor access.*
- *If supported leverage no more than two SSIDs.*

Machine Type	Auth	Encryption	Key	FW from District	WS Login	Filtering
District Owned - Windows	802.1x (AD Mach. Auth)	WPA2 Enterprise	802.1x Generated	No	AD	Force login of non-authorized systems
District Owned – Non Windows	802.1x Or WPA2 (Mac or Single AD User) (1)	WPA 2 Enterprise or Personal	Well Known Key (2)	No	(3)?	Force login of non-authorized systems
BYOD	802.1x Or WP2 (AD Mach. Auth)	WPA 2 Enterprise or Personal	Well Known Key (2)	Yes	N/A	Force login of non-authorized systems
Guest	Splash Page with Auth. System - AUP	none Authentication	none Generated	Yes	N/A	Default
VoIP	MAC on Wireless Controller	WPA 2 Personal	Well Known Key (2)	No	N/A	None

4.2 Advanced Network Protocols

- Is support Wi-Fi Multimedia for quality of service (QoS) needed?
- Is support of VoIP wireless handsets needed?
- Is support for multicast frames needed?
- Do you leverage AppleTV's or Chromecast devices for display mirroring?
- Are students allowed to use the AppleTV and Chromecast devices?
- Student/Faculty printing capabilities?
- If using Video what video service is used?

Default design without specific input

Wireless Network Design Considerations

- *Enable Wi-Fi Multimedia (WMM) for Voice QoS and requirement for 802.11N/AC*
- *Enable Call Admission Control (CAC)*
- *Ensure ability to control mDNS (Bonjour) traffic*
- *Enable airtime fairness.*
- *Enable broadcast/multicast suppression.*

4.3 Location-Based Services

- Are location-based services required? Do RFID Passive and Active Tagging require additional costs?
- What is the documented proximity to the asset that is needed?

Default design without specific input

- *Include location services, with accuracy within 5 meters*
 - *Location is a factor of AP density and diagram accuracy*

4.4 Unified Communications:

- Wireless VoIP, are you considering vender specific solutions such as:
 - Channel scanning
 - Jabber
 - Lync

Default design without specific input

- *Consider separate SSID for function specific device.*
- *For multi-function devices – i.e. laptop doing video call consider vender application awareness specific solutions.*
- *Enable Wi-Fi Multimedia (WMM) for Voice QoS*
- *Enable Call Admission Control (CAC)*
- *Ensure ability to control MDNS (Bonjour) traffic*
- *Enable airtime fairness.*
 - *Enable broadcast/multicast suppression*
 - *Use 5 GHz only with AP power levels of 15dBm and signal boundary of -68dBm.*
- **NOTE:** *Outside of an AP per classroom model always Survey using 5 GHz only with AP power levels of 15dBm and signal boundary of -68dBm. For VoIP planning leverage the same as above but -65dBm boundary*

Wireless Network Design Considerations

References

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